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(54) PROCESS AND APPARATUS FOR STRETCHING A TUBULARLY-FORMED SHEET OF A THERMOPLASTIC MATERIAL AND THE PRODUCT PRODUCED THEREBY

(71) We, BIAX-FIBERFILM CORPORATION, a corporation organized and existing under the laws of the State of Wisconsin, United States of America, of 1066 American Drive, Neenah, Wisconsin, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to a novel process and apparatus for the stretching of a tubularly-formed sheet of thermoplastic material and more particularly to a novel process and apparatus for the bi-axial stretching of a tubularly-formed sheet of orientable, polymeric thermoplastic material to form bags of improved strip tensile breaking strength.

Thermoplastic bags for diverse use, such as sandwich bags, garbage bags, leaf bags and the like, are produced by extruding a tube of thermoplastic material, such as high density polyethylene, with the resulting tubularly-formed material being cooled, heat sealed and either scored or cut to the desired length. The thus formed bag exhibits a strip tensile breaking length representative of the processed thermoplastic material. The end use of the thermoplastic bag normally dictates the selection of the thermoplastic material, e.g. as a sandwich bag, a low porosity and normal strength thermoplastic material is selected whereas a garbage bag would require the selection of a thermoplastic material exhibiting high strength characteristics.

It is an object of the present invention to provide a novel process and apparatus for stretching a heat-sealable and tubularly-formed sheet of a synthetic material.

Another object of the present invention is to provide a novel process and apparatus for bi-axially stretching a collapsed heat-sealable and tubularly-formed sheet or web of thermoplastic material to form a bag having an improved strip tensile breaking strength of at least twice that of the tubularly-formed sheet of thermoplastic material being treated; in effect, providing a significant and unexpected result in that both the heat seal area and the fold area increase in strength, in addition to the film area.

Various other objects and advantages of the present invention will become apparent from the following detailed description of an exemplary embodiment thereof with the novel features thereof being particularly pointed out in the appended claims.

In accordance with the present invention, there is provided a process and apparatus for the selective stretching of a tubularly-formed sheet or web of thermoplastic material in a station provided with a set of grooved, generally sinosoidally-shaped rolls, whereby the sheet or web of thermoplastic material is stretched in a manner to effect uniform stretching thereby producing a sheet or web of larger dimension in the direction of stretch.

In accordance with a preferred embodiment of the present invention, there is provided a process and apparatus for bi-axially stretching a tubularly-formed and heat-sealed sheet of thermoplastic material in a first station and a plurality of second stations wherein the first and second stations are provided with sets of rolls having grooves perpendicular and parallel, respectively, to the axis of each set of rolls. The groove pattern of each set of rolls is such that the distance between grooves is less than 1.0 millimeters times the sheet or web basis weight in grams per square meter. The sheet or web of tubularly-formed thermoplastic material is stretched in a manner to effect uniform stretching to produce a thermoplastic bag of substantially improved strip tensile breaking strength.

The invention will be more clearly understood by reference to the following detailed description of an exemplary embodiment thereof in conjunction with the accompanying

drawings wherein:

Figure 1 is a schematic side elevational view of the apparatus and process of the present invention; and

Figure 2 is a schematic top elevational view of the apparatus and process of the present invention.

Drive and support assemblies, timing and safety circuits and the like, known and used by those skilled in the art, have been omitted in the interest of clarity.

Referring to Figure 1, there is illustrated a preferred embodiment of the process and apparatus of the present invention including a circular blown film die assembly and a stretching assembly, generally indicated as 10 and 12, respectively. The circular blown film die assembly 10 forming the blown film 12 may be any one of the types of assemblies sold by the Sterling Extruder Corporation of South Plainfield, New Jersey. The blown film 12 is passed about the roller 14 to form a flat two-layered sheet 16 prior to introduction into the heat sealing assembly, generally indicated as 18, as known and used by those skilled in the art, wherein the two layered sheet is heat sealed at selected intervals on a line perpendicular to the movement of the sheet 16.

The thus heat-sealed, two-layered sheet 20 is coursed in a first station, generally indicated as "I" between a nip 22 of a pair of rollers 24 having a plurality of grooves 26 perpendicularly formed to the axis of the rollers 24, as seen in Figure 2. The sheet 20 is maintained against the lower grooved roller 24 by a pair of press rollers 28 to hold the sheet 20 against the lower roller 28 to thereby prevent the sheet 20 from narrowing prior to introduction. Once in the nip 22, the sheet 20 assumes the shape of the groove pattern and becomes stretched by a factor of the draw ratio as hereinafter more clearly described.

In the first station, in effect, lateral stretching, the sheet 20 is wound up at about the same velocity as the feed velocity. The crimp pattern is flattened out by stretching the sheet 20 laterally, such as by means of tenter clamps or curved Mount Hope rolls, generally indicated as 32, such as known and used by one skilled in the art.

The grooves 26 of the rollers 24 are intermeshed like gears, as shown to those skilled in the art. As the sheet 20 enters the nip 22, the sheet 20 assumes the shape of a groove 26 and is stretched by a factor determined by the length of the sinus wave "ℓ" of the groove divided by the original length of the web "ω" between contact points of each respective groove tip as disclosed in British Patent Specification No. 1,521,183.

The draw ratio ℓ/ω is calculated by the following equation where

$$a = \pi\, d/2\, \omega$$

and the sinus wave of the groove is

$$\ell/\omega = \int_{0}^{\pi} \frac{\sqrt{1 + a^2 \cos^2 x}}{\pi}\, dx$$

Thus for d/ω ratios of 1.0, 0.75 and 0.5 the draw ratios are 2.35, 2.0 and 1.6, respectively.

A laterally stretched sheet 34 is passed from the rollers 32 and is coursed between a nip 40 of a first pair of rollers 42 of a second station "II" with said rollers 42 having a plurality of grooves 44 parallel to the axis of the rollers 42. The sheet 32 is maintained against the lower grooved roller 42 by a pair of press rollers 46 to ensure that the velocity V_1 of the sheet 32 is substantially identical to the surface velocity V_1 of the grooved rollers 42. The grooves 44 of the rollers 42 are intermeshed like gears, as known to those skilled in the art. As the sheet 34 enters the nip 40, the sheet 34 assumes the shape of a groove 44 and is stretched by a factor determined by the length of the sinus wave "ℓ" of the groove divided by the original length of the web "ω" between contact points of each respective groove tip, as hereinbefore discussed with reference to the passage sheet 20 through station I rollers 24.

The sheet 34, after passage through the nip 40 of the rollers 42, is pulled away by a pair of tension rollers 48 having a surface velocity V_2 greater than the surface velocity of the rollers 42, but not greater than a factor of the draw ratio affected in the nip 40 of the rollers 42.

Accordingly, the length of the sheet 34 is therefore increased by such factor. It is noted that the sheet 34 does not undergo narrowing while being longitudinally stretched or extended, as is the case with conventional roller systems. In a preferred embodiment of the present invention, the sheet 34 is passed through two further pairs of grooved rollers 42 to further stretch lengthwise the sheet 34 which is eventually collected on a roller 50.

The maximum permissible draw ratio can easily be determined by measuring the residual elongation of the thermoplastic material. For best results, the grooves 44 of the rollers 42 should be as fine as possible, with groove distance being increased if heavy basis weight factors are to be oriented. From experience, good results are obtained, if the distance between grooves (in mm) is less than 1.0 times the fabric basis weight (in gram/m^2). With the process and apparatus of the present invention, a bag is produced having a much higher strip tensile breaking length (STBL - expressed as meters) than a normal produced blown film bag.

Operation of the process and apparatus is described in the following examples which are intended to be merely illustrative, and the invention is not to be regarded as limited thereto.

Example I

A 7" × 7" double layer sheet is formed by extruding a mixture of 90% polypropylene (melt flow rate of 0.5 g/mm) and 10% clay and had the following properties:

thickness 0.050"	: 127 micron
film basis weight	: 125 g/m^2
STBL	: 3570 m
break elongation	: 1600%
initial modulus	: 1600 m
STBL over seal	: 2560 m
STBL over fold	: 3050 m

The bag was heat-sealed and stretched in the apparatus 1.5 times on a lateral direction and 3.3 times on a longitudinal direction (3 passes) to a final dimension of 10.5" wide and 23" long. It was noted that the heat-sealed area also stretched. The stretched bag had the following properties:

STBL	: 23550 m
break elongation	: 40%
initial modulus	: 185500 m
STBL over seal	: 15500 m
STBL over fold	: 16600 m

Example II

The process of Example I was repeated on a similar 7" × 7" sheet with heat sealing being effected after stretching vice before with the STBL over seal being 2200 m ; i.e. less than the STBL over seal of a bag heat sealed before stretching.

Example III

A 7" × 7" double layer sheet is formed by extruding a 100% polypropylene (melt flow rate of 6.0 g/10 mm) and had the following properties:

thickness 0.050"	: 150 micron
film basis weight	: 142 g/m^2
STBL	: 3200 m
break elongation	: 1400%
initial modulus	: 14500 m
STBL over seal	: 14500 m
STBL over fold	: 3040 m

The bag was heat-sealed and stretched in the apparatus 1.5 times on a lateral direction and 4.5 times on a longitudinal direction (3 passes) to a final dimension of 10.5" wide and 31.5" long. It was noted that the heat-sealed area also stretched. The stretched bag had the following properties:

thickness	: 25 microns
basis weight	: 21 g/m^2
STBL	: 35700m (length)
break elongation	: 25%
initial modulus	: 225000 m
STBL over seal	: 18400 m
STBL over fold	: 22050 m

Example IV

A 7" × 7" double layer sheet is formed by extending a mixture of 95% high density polypropylene (melt flow rate of 2.0 g/10mm) and 5% titanium dioxide and had the following properties:

thickness	: 200 micron
film basis weight	: 170 g/m^2
STBL	: 3800 m
break elongation	: 1800 %
initial modulus	: 12000 m
STBL over seal	: 2600 m
STBL over fold	: 2650 m

The bag was heat-sealed and stretched in the apparatus 2.0 times (2 passes) on a lateral direction and 5.0 times on a longitudinal direction (3 passes) to a final dimension of 14.0" wide and 25" long. It was noted that the heat-sealed area also stretched. The stretched bag had the following properties:

thickness	: 22 microns
basis weight	: 18 g/m^2
STBL	: 38500 m
break elongation	: 40%
initial modulus	: 17500 m
STBL over seal	: 28500 m
STBL over fold	: 30400 m

Thus, it is readily apparent to one skilled in the art that a novel bag is produced of a light weight per dimension exhibiting substantially improved strip tensile breaking length. It will be readily apparent to one skilled in the art, that depending on end use, that a bag of improved strip tensile breaking length may be produced by passing a tubularly-formed thermoplastic sheet, preferably heat-sealed, either through laterally or longitudinally grooved rollers or sequentially through such grooved rollers or as described herein with reference to the preferred embodiment.

Reference is made to our copending British Patent Application No. 8024172 (Serial No. 1598738), which is divided on the present application and claims a receptacle comprising a cylindrically-shaped wall formed of stretched orientable polymeric material heat sealed at an end thereof; said wall being characterized by a strip tensile breaking length of at least twice the strip tensile breaking length of non-stretched orientable polymeric material.

WHAT WE CLAIM IS:

1. A process for longitudinally stretching a tubularly-formed sheet of orientable polymeric material including heat-sealing said tubularly-formed sheet at preselect intervals perpendicular to the movement of said sheet prior to stretching; introducing said sheet into a nip of interdigitating rollers having grooves parallel to the axis of said rollers; controlling the velocity of introduction of said sheet into said nip to substantially the peripheral speed of said rollers thereby to longitudinally stretch incremental portions of said sheet; withdrawing said sheet from said rollers at a velocity greater than the rotational velocity of said rollers; and collecting the thus stretched sheet.

2. A process according to Claim 1, wherein the withdrawal velocity from said rollers is not greater than a factor of the draw ratio of said nip.

3. A process according to Claim 1 or 2, including introducing said sheet into a nip of interdigitating rollers having grooves perpendicular to the axis of said rollers; controlling the velocity of introduction of said sheet into said nip of substantially the peripheral speed

of said rollers thereby to laterally stretch incremental portions of said sheet; laterally elongating and withdrawing said sheet from said rollers at a velocity substantially corresponding to the velocity of introduction; and collecting the thus stretched sheet.

4. A process according to Claim 3, including repeating the process of introducing said sheet into a nip of interdigitating rollers having grooves perpendicular to the axis of said rollers; controlling the velocity of introduction of said sheet into said nip to substantially the peripheral speed of said rollers thereby to laterally stretch incremental portions of said sheet; and laterally elongating and withdrawing said sheet from said rollers at a velocity substantially corresponding to the velocity of introduction prior to collecting the biaxially stretched sheet.

5. A process according to Claim 4, including twice repeating said process.

6. The product produced by the process of any one of the preceding claims.

7. An apparatus for producing thermoplastic bags which includes means for extruding a tube of orientable polymeric material; means for forming said tube into a sheet; means for heat sealing said sheet at preselected portions thereof; a first station means for stretching said sheet in a first direction and including a first set of interdigitating rollers formed with grooves, said first set of interdigitating rollers stretching incremental portions of said web in a first direction; first regulator means for controllably introducing said sheet into said first set of interdigitating rollers; a first take-up means for elongating said sheet in said first direction upon withdrawal of said sheet in said first set of interdigitating rollers; a second station means for stretching said sheet in a second direction and including a second set of interdigitating rollers formed with grooves, said second set of interdigitating rollers stretching incremental portions of said sheet in a second direction; a second regulator means for controllably introducing said sheet into said second set of interdigitating rollers; a second take-up means for elongating said sheet in said second direction upon withdrawal of said sheet from said second set of interdigitating rollers; and collecting means for receiving said sheet.

8. An apparatus according to Claim 7, wherein said first and second set of interdigitating rollers are formed with grooves which are perpendicular and parallel, respectively, to said first and second sets of interdigitating rollers.

9. An apparatus according to Claim 7 or 8, wherein said second take-up means are press rollers operated at a rotational velocity proportional to the draw ratio effected in said second set of interdigitating rollers.

10. An apparatus according to any one of Claims 7 to 9, wherein said second regulator means include a roller rotating at substantially the same rotational velocity as that of an associated interdigitating roller.

11. A process for longitudinally stretching a tubularly-formed sheet of orientable polymeric material substantially as described herein with reference to the accompanying drawings.

12. An apparatus for producing thermoplastic bags substantially as described herein with reference to the accompanying drawings.

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1598737 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

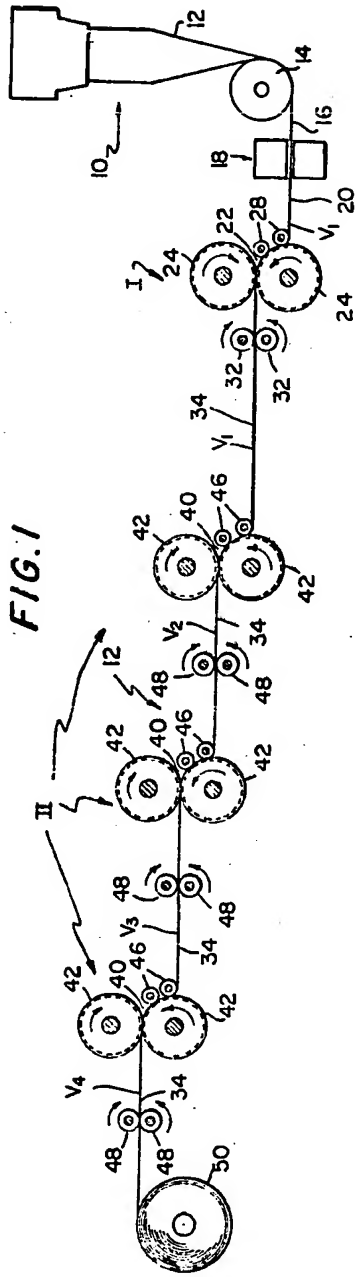

FIG. 1

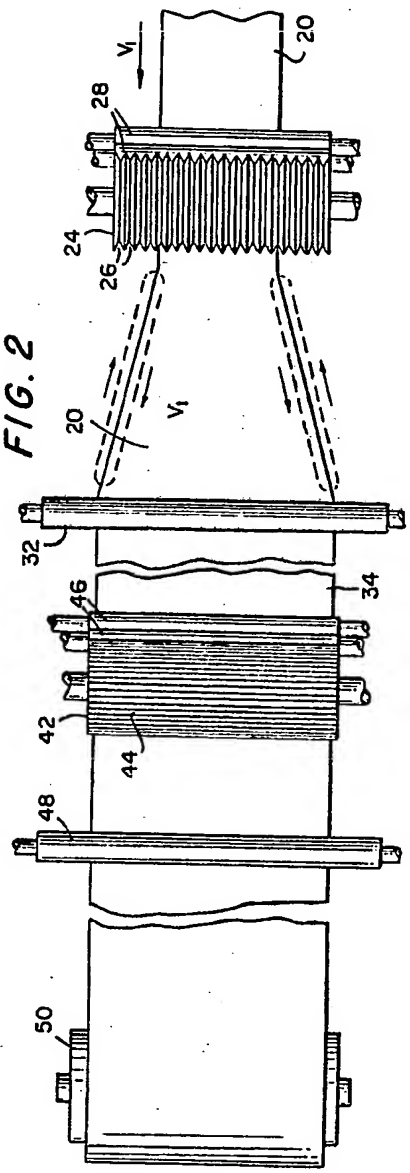

FIG. 2